Beyond

Professionals in almost every discipline now use technology-based tools to think in new ways

COMPUTERS AND THE INTERNET already play several important roles in liberal education.

1. *Computer literacy and fluency*: the ability of students to use computers and the Internet as tools for general purposes
2. *Effectiveness:* the use of technology to foster faculty-student connections, student-student collaboration, active learning, and other practices that can improve outcomes
3. *Access:* the use of technology to support programs and practices that are fully available to nontraditional learners who would otherwise be unable to enroll and excel

All three of these applications are well established and growing. Now there's another application of technology to liberal education to consider:

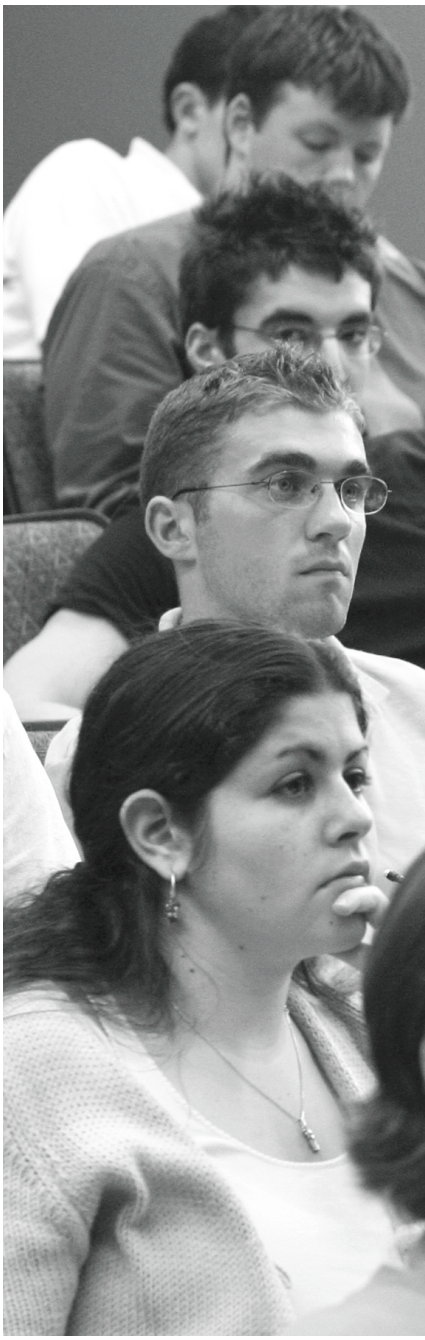
4. *Content:* Computers and the Internet, as they're used in the larger world, have implications for what all college students, by the time they graduate, should have learned from their majors as well as from general education requirements. These implications go far beyond computer literacy.

What students should learn

These changes in content, too, are already in motion, although they're at an earlier stage than the first three. A recent AAC&U report, *Our Students' Best Work*, specifies five key educational outcomes for liberal education (2004, 5-6).

1. strong analytical, communication, quantitative, and information skills
2. deep understanding of and hands-on experience with the inquiry practices of disciplines that explore the natural, social, and cultural realms
3. intercultural knowledge and collaborative problem-solving skills
4. a proactive sense of responsibility for individual, civic, and social choices
5. habits of mind that foster integrative thinking and the ability to transfer skills and knowledge from one setting to another

For each of these five, computers and the Web are already beginning to affect faculty thinking about what all students should learn, and how.



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Computer Literacy

Implications of Technology for the Content of a College Education

Indiana University

First outcome

"Strong analytical, communication, quantitative, and information skills—achieved and demonstrated through learning in a range of fields, settings, and media, and through advanced studies in one or more areas of concentration" (AAC&U 2004, 5).

Today there are important types of analytical thinking, communication, quantitative reasoning, and information skills that cannot be used, or learned, without technology. Let's look at just two: information literacy and the ability to create Web sites as a medium of academic expression.

Information literacy is the set of skills needed to find, retrieve, analyze, and use information in a library, on the Web, or anywhere else. Virtually all majors require some form of information literacy, which almost always requires knowing how to use a maze of information on the Internet, as well as print resources. Information literacy, like writing across the curriculum, is learned via a series of assignments and feedback on those assignments that should occur frequently and throughout the student's course of study.

Earlham College's Diana Punzo, associate professor of psychology, talks about how computers have changed the process of research in her discipline. "When I was a student, we didn't use computers. You had to spend hours thumbing through indices of the literature. Now the process is far more efficient and students can focus on the literature itself and the process of research." In course after course, psychology students at Earlham get briefings from librarians and do research on the literature. They learn, for example, the difference between using "racism" and "prejudice" as search terms. Faculty members coordinate their efforts informally, talking about these skills and other facets of the curriculum in biweekly departmental meetings.

Over the years, students learn skills that are manifested and assessed in a senior year capstone experience. For psychology majors at Earlham, the capstone experience is a multipart project. In one piece of it, students are each given an article written for the general public (e.g., from a newspaper). They have to search and interpret the academic literature on the topic and then write an analysis of the article, also geared to the general public. In another part of this capstone, seniors do an experimental project and must search and analyze the relevant research literature. These capstone projects are each graded by a pair of faculty who examine, among many other things, the students' use of the literature.

Student-created Web sites as a medium of academic expression: Imagine a course on nineteenth-century English literature or a course on the politics of urban neighborhoods. Multimedia projects offer several distinctive advantages for learning and assessment. Here are just a few:

- Student authors of Web sites can include evidence such as pictures, audio recordings, video clips, databases, and live links to references. Providing the reader with direct access to the supporting evidence also puts more pressure on the student to explain why the evidence is being cited instead of just inserting a terse "Smith 1996" and moving on.
- When creating a Web-based project, students can create an argument that operates on several levels: a summary form of the argument that links at several points to more detailed explanations, data, and responses to anticipated objections.
- One of the most educationally important features of creating Web-based projects is the option of expanding the audience. The implications of this shift surprised the faculty and students who initially tried it. For example, in 1995 Bosnian peace talks began in Dayton, Ohio. Not far away, students in a journalism course at Miami University were asked to create a Web site with background on the conflict and the peace talks. Professor Linda Crider wrote later that students quickly received e-mail criticisms to their site from as far away as Bosnia. The students were shocked, but soon, Crider wrote, she was shocked more than they were because she had never seen students work that hard. Suddenly this assignment was real and they didn't want to be embarrassed in front of the world. Students today can create projects for use by other students (students who take the course in future semesters or students in the public schools, for example) or as parts of internships. Later in this article, we'll see some examples of such projects.

As with their skills of writing or information literacy, students usually cannot learn how to use the Web as a medium for thought and communication in just a single course. The more courses that encourage or require students to create multimedia projects in addition to writing papers, the easier it becomes

for each new faculty member to take advantage of, and further develop, this new and important skill. The University of Southern California's Institute of Multimedia Literacy is a leader in this area, providing faculty development and support across the institution. Starting in fall 2004, USC is offering a new honors program in multimedia scholarship to help lead the way in further development of undergraduate skills. Sixty students from twenty-five different departments have been admitted to this four-year program. Stanford is also taking steps to foster multimedia literacy across the curriculum: the university's new required second-year course in communications includes development of multimedia by students, along with writing and oral presentation.

Second outcome

"Deep understanding and hands-on experience with the inquiry practices of disciplines that explore the natural, social, and cultural realms—achieved and demonstrated through studies that build conceptual knowledge by engaging learners in concepts and modes of inquiry that are basic to the natural sciences, social sciences, humanities, and arts" (AAC&U 2004, 5).

Professionals in almost every discipline now use technology-based tools to think in new ways. For example, statisticians explore data differently now, using new statistical procedures and displaying results graphically. Technology-based tools enable relative novices to ask meaningful questions of their own—literature students learning a bit about inquiry in biology, and vice versa. In addition to these "power tools for novices," technology is playing other roles in helping people from all fields learn skills of inquiry.

In order to attract and educate students, science literacy programs often use active forms of learning. At West Point, for example, all students must learn math and science. In calculus courses, students are told that they have captured a number of perfectly serviceable cannons with plenty of ammunition. Unfortunately, however, the operations manuals are missing, so the students must experiment. They are allowed to measure the distance the ball travels when the cannon is fired at one particular angle.

Working in teams with their laptop computers and using theory learned in physics and calculus, students must then deduce muzzle velocity. With that information and some more physics, they should be able to figure out the appropriate angle of elevation to hit any target so long as they know the target's distance and elevation. Each team gets a different target and only one shot. Visiting a calculus class at the right moment, one can see cheering students who've just hit a distant target with the first shot of their toy cannon. West Point uses a number of such games, often based on simulations, to help all students learn to think the way that scientists and engineers do.

Physics and calculus are not the only realms of science literacy where technology can play a transformative role. BioQUEST creates, collects, and distributes realistic research simulations in biology. BioQUEST values the "Three P's":

1. Problem posing: creating a research problem to do in the simulated world, such as a genetics experiment or a biochemical analysis
2. Problem solving: carrying out the research and developing a conclusion based on the evidence
3. Persuasion: persuading first a peer and then the instructor that the experimental evidence is sufficient to support the student's conclusion

One nice feature of the BioQUEST software is that not even the instructor can "open" the simulation to find the right answer. The instructor, like the peers and the student investigator, must examine the chain of experiments and the resulting evidence in order to grade the student's work.

Third outcome

"Intercultural knowledge and collaborative problem-solving skills—achieved and demonstrated in a variety of collaborative contexts (classroom, community-based, international, and online) that prepare students both for democratic citizenship and for work" (AAC&U 2004, 5).

Imagine an undergraduate from suburbia reading a translation of *Beowulf* or studying a novel of Appalachia. How can the student develop a deeper understanding of another culture where familiar words may not have familiar meanings? How can the student express that understanding in a form that allows feedback? In two different courses Professor Patricia O'Connor of Georgetown University has

Electronic portfolios offer an ideal infrastructure for the development of all the outcomes of liberal education

asked her students to create Web sites that annotate text from their readings. Students link each selected word and phrase to illustrate commentary about their meaning in context; terms used in the commentary are themselves linked to other such commentaries, creating a web of description of that culture. Andrew Owen, one of O'Connor's students, analyzed a brief passage from *River of Earth*, a novel by James Still set in Appalachia. Dozens of phrases and terms such as "patriarchy," "God's green earth," and "homeplace" were analyzed and illustrated with archival images. Owen's analysis, like the culture it depicts, has no beginning or end—each narrative annotation stands partly on its own, but it is interlinked with, and given further meaning by, several other such annotations.

Technology is making more direct learning about other cultures possible, too. For example, "Raison d'Etre" is a project conducted jointly by the University of South Carolina, Lycée Paul Héroult, and Dickinson College. Students learning French in the United States interact regularly with students in France who are majoring in English. They correspond weekly, engage in regular chat sessions, and use Web cams as they talk about one another's cultures. The project won a 2003 National Award from the American Council of Education's AT&T Program on Technology as a Tool for Internationalization.

Another ACE/AT&T national award-winner was Ball State University's Global Media Network. Thirteen institutions on five continents are members. The technology they share makes it possible to have highly interactive class meetings with faculty and students from pairs of institutions. Imagine a conference table with faculty and students from an American institution and a university in Korea seated around it and talking with one another. A major goal of the program is to provide initial international exposure to lower-division students in the university's core curriculum.

These are just two examples of how technology can open gateways into other cultures from a distance. Technology can also make it easier, and more productive, to study abroad, as the next section describes.

Shorter College

Fourth outcome

"A proactive sense of responsibility for individual, civic, and social choices—achieved and demonstrated through forms of learning that connect knowledge, skills, values, and public action, and through reflection on students' own roles and responsibilities in social and civic contexts" (AAC&U 2004, 6).

Worcester Polytechnic Institute (WPI) has had for thirty years one of the most exciting programs in engineering education. For example, the Interactive Qualifying Project, typically done in the junior year, requires students to apply what they've learned in their majors to problems of social significance. Surprisingly, half of WPI's students go abroad to do this project these days. Technology seems to have a subtle but spectacular impact on the feasibility of study abroad. The Web allows students to define and prepare for their projects long before they and their faculty advisors travel to London, Thailand, or any of WPI's more than twenty other off-campus sites. And digital communications (including cell phones that WPI provides the students and faculty) make it easier for them to be so

far from campus for seven or eight weeks while working on their projects.

Last year, for example, seven student teams and two faculty advisors traveled to WPI's London site. One of those student teams, composed of students from several engineering programs, was assigned to respond to a request for help from the municipal government of the borough of Merton, a London suburb. A new census of the UK had just been done, and the planning unit wanted the students to prepare a display of the data relevant to the borough, perhaps a sixty-page book of the sort that had been created for the previous census, a decade earlier.

Working with other students and with their faculty advisors in a preparatory course, two months before leaving for London, the students were guided into asking questions about this task. How was the book used in the last ten years? By whom? For what? This dialogue led the students and the borough to redefine the task: the four-student team would create a Web-based resource for mapping and analyzing census data. Professor Paul Davis, a mathematician who was one of the faculty supervisors of the London site and is dean of interdisciplinary and global studies at WPI, commented, "In terms of liberal education, this is a key step, where students are grappling with open-ended issues and trying to form a project they can do in the weeks they're on site. They identified the problem as helping policy makers visualize deprivation on maps of the borough."

In London, the WPI students created a geographic information system that turned indices based on census data (such as number of toilets per resident in buildings) into maps. The maps helped planners identify a swath of poverty that crossed the boundary from Merton into a neighboring borough. In an "aha!" moment, the planners realized that they could collaborate with that borough in applying for funds to work on the problems, rather than competing with it for funds as they had in the past.

Professor Davis commented, "The lesson we think the students carried away was that the technology, well used, could inform important social decisions. They also realized they hadn't solved the problem of deprivation or even answered all the possible questions. Instead they got a sense of technology's possibilities and limits, the complexity of social issues, and the political and social environment in which those problems exist. From our perspective those are all successes for liberal education."

Fifth outcome

"Habits of mind that foster integrative thinking and the ability to transfer skills and knowledge from one setting to another—achieved and demonstrated through advanced research and/or creative projects in which students take the primary responsibility for framing questions, carrying out an analysis, and producing work of substantial complexity and quality" (AAC&U 2004, 6).

Many of the approaches to teaching described above have dealt with integrative thinking and the ability to apply what has been learned in one context to an unfamiliar problem or setting. This ability to think about your own thinking doesn't develop automatically while studying in traditional courses, as Professor Sharon Hamilton discovered in her teaching at Indiana University Purdue University Indianapolis (IUPUI). She and her colleagues asked students to reflect on their learning in relation to artifacts the students had uploaded on the electronic portfolios. Hamilton commented, "There were several top-notch writing students in the pilot, and I was eager to read their reflections." One student, who had uploaded a thoughtful analysis and synthesis of a group of novels of the South as an example of her ability, wrote,

> Reflection involves analysis and synthesis to come to a new understanding. In this paper, I analyzed six novels and synthesized their approaches to the role of women in the South. I learned a lot about different perceptions of women in the South from this critical thinking.

"And that was . . . one of the top achieving students in the group!" Hamilton exclaimed. "It became evident to me that students require instruction and support for their reflective writing."

Electronic portfolios

IUPUI accelerated its work with electronic portfolios. Portfolios have been used for centuries in disciplines such as architecture and the arts. A portfolio is a thoughtfully organized collection of student work, usually including work other than, or in addition to, traditional academic papers. Portfolios also often include student reflections about how the project demonstrates their developing skills. These

reflective statements are one way in which portfolio use is intended to deepen student learning. Alverno College in Milwaukee pioneered the use of portfolios in liberal education starting in the 1970s, using them to chart student progress in developing competencies required of all students by graduation.

What seems most important for each institution is that some level of technology be extremely reliable

Electronic portfolios store those projects, or recordings of them, plus reflections and feedback, on computers so that these records can easily be accessed online. For example, Web projects can be stored in portfolios, as can video recordings of student performances (oral presentations, participation in teams, dances). In contrast to paper portfolios, the online portfolio can organize the projects in several different ways: one "view" organized for an individual course, another view organizing the content to show progress toward goals of liberal education, another showing progress in the major, and yet another that might be used for employment or graduate school applications. The work can be used over a period of time by the student, by faculty, and, at some institutions, by people outside the institution (e.g., potential employers). This ability to revisit a project long after the project is completed is one of many distinctive values of electronic portfolios.

Electronic portfolios offer an ideal infrastructure for the development of all the outcomes of liberal education described in this paper—doubly so because, as we've seen, a growing proportion of student work in all these areas is being done with computers and Internet resources.

Bit by bit, putting it all together

Electronic portfolios have at least one other kind of significance for changing the content of a college education: they can help faculty members, as a group, see what's going on and guide curricular change. In the past, college education has resembled an elephant designed by a committee of blind men, each faculty member teaching a course while knowing almost nothing about teaching and learning inside courses taught by other faculty. Electronic student portfolios can be used to change that.

Some of the impacts of student portfolios are subtle. For example, at Alverno faculty need to designate "Key Performances" in each course—assignments, assessments, and projects that represent the most important goals for the course and, usually, for meeting requirements of the major and for graduation from the college. These Key Performances, including descriptions, criteria, student self-assessments, and faculty feedback, are visible to other faculty. Linda Ehley, associate professor of computer science at Alverno, reports that this ability to see, and be seen, provides a basis for both collaboration and faculty development.

Other impacts of student portfolios on the ability to plan are more obvious and strategic. Clemson Provost Doris Helms comments that electronic portfolios have "freed us to think about general education as something other than a smorgasbord of courses." Clemson is using portfolios to collect student projects that are intended to demonstrate progress toward institutional educational goals. Portfolios used in this way require faculty to work together in describing the intellectual achievement represented by student work: first, to frame the goals, and then, to provide feedback to students about whether they've provided adequate evidence of progress toward meeting those goals for graduation. Provost Helms told me, "We'll not only assess student work but also use student portfolios for research—*where* are students learning what they're learning? For example, what are students learning while outside the classroom, in jobs, at home, and in extracurricular experiences? What kinds of learning should we foster, more intentionally, outside the course?" So the electronic portfolio can also provide data for scholarship of teaching and learning by the faculty working as a research team. Helms said that such a use of portfolios

A companion Web site to this article contains URLs for many of the examples described below as well as other references. We hope readers will contribute additional examples that can be added to this Web site.

www.tltgroup.org/resources/GX/Home.htm

would not have been feasible at a large public institution such as Clemson without the online dimension.

Three conditions are critical if student portfolios are to provide a tool for collaborative planning by faculty:

1. Faculty need to collaborate in deciding what kinds of learning are to be charted by the portfolio.
2. Faculty need to collaborate in assessing at least some aspects of student progress.
3. Faculty need to use what they learn from assessment to consider whether and how to change the goals, the curriculum, their teaching, and assessment.

When portfolios are used that way, the doorway to rapid, intentional evolution of liberal education opens.

Concluding thoughts

The changes in the content of a college education described above have several common elements.

First, students use the technologies as a tool more often than as a "teacher": these uses of technology alter and enhance the role of the faculty member. The more powerful and widely used the technology, the more invisible it becomes to both students and faculty. They think with the technology rather than thinking about it. In fact, one reason that faculty are finding some of these changes relatively easy to make is that they themselves already use these technologies in their research and their lives outside the college.

Second, technology widens the range of experiences and resources available to the student, which creates an even greater need to help students learn use such freedom, rather than floundering in it. More than ever, college needs to help students learn how to learn.

Third, the curricular changes described in this article require a mix of bottom-up, incremental changes coming out of individual courses and top-down, strategic changes (e.g., portfolios) that come out of faculty and administrative leadership.

Fourth, there is no magic level of technology that an institution needs before such changes can begin. I've seen examples of such changes in the content of education for almost a quarter century now, the earliest ones relying on Apple II computers. But the pace is accelerating, especially now that most students can use computers and the Internet as personal tools. What seems most important for each institution is that some level of technology be extremely reliable. When people no longer need to think consciously about their skills or worry overmuch about things breaking down, that particular technology achieves a certain invisibility. How many people still think of word processing as "technology?" Once that happens, faculty and students can think about advancing education instead of just about advancing technology. Institutional leadership comes from a thoughtful, committed coalition of faculty, administrators, students, and alumni, not from cutting edge technology.

Indiana University–Purdue University Indianapolis

This is an extraordinarily exciting moment in the evolution of liberal education. This article has mentioned a number of institutions that are currently among the leaders in redefining the curriculum. The chances are excellent that, in five years, additional institutions will have leapfrogged forward, drawing international attention to their academic programs. Their fame will not come from having (for a brief moment) the newest of the new technologies. Instead, these institutions will attract attention and resources because they have helped redefine what it means to be an educated person in the twenty-first century. □

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